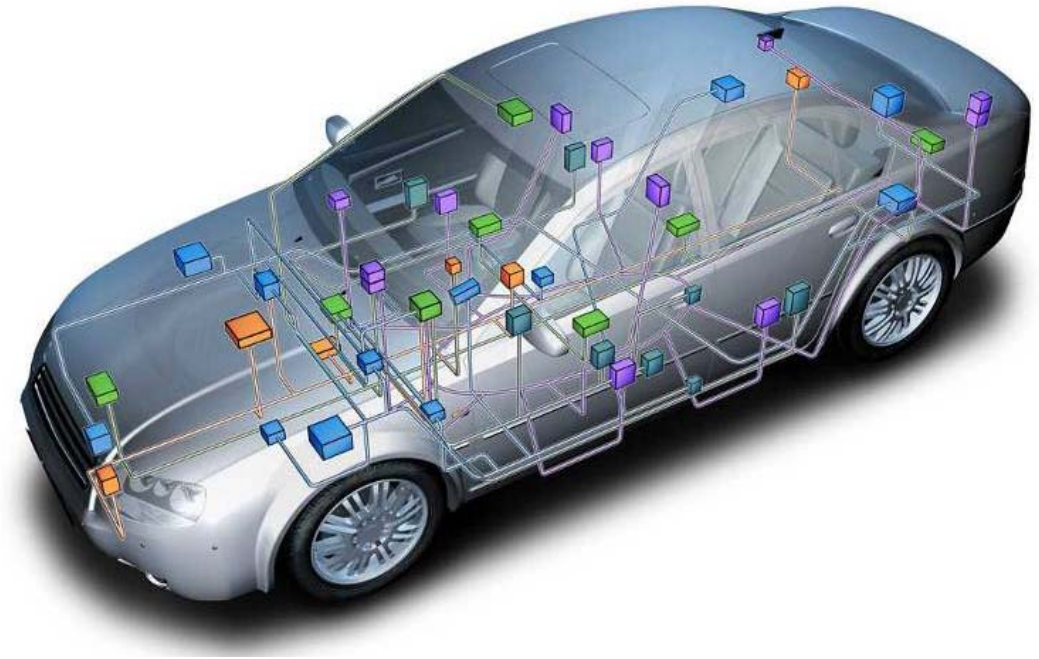
Mastering the Challenges in Embedded Software Development



October 6th, 2008

Dr. Juergen Moessinger
Vice President
Automotive System Integration
Robert Bosch GmbH

Agenda

- Bosch Group
- Challenges in Automotive Development
- Solutions
  - Architecture Based Development – SW Reuse
  - Processes
- Conclusion – Implementation at Bosch
- Summary

Structure of the Bosch Group

Business sectors

Bosch Group
Sales: 46.3 billion euros[1)]
Associates on Jan. 1, 2008: 271,000

Automotive Technology
Sales: 28.4 billion euros
Share of total sales: 61 %

Industrial Technology
Sales: 6.0 billion euros
Share of total sales: 13 %

Consumer Goods & Building Technology
Sales: 11.7 billion euros
Share of total sales: 26 %

[1)] Including other business areas

Bosch Group

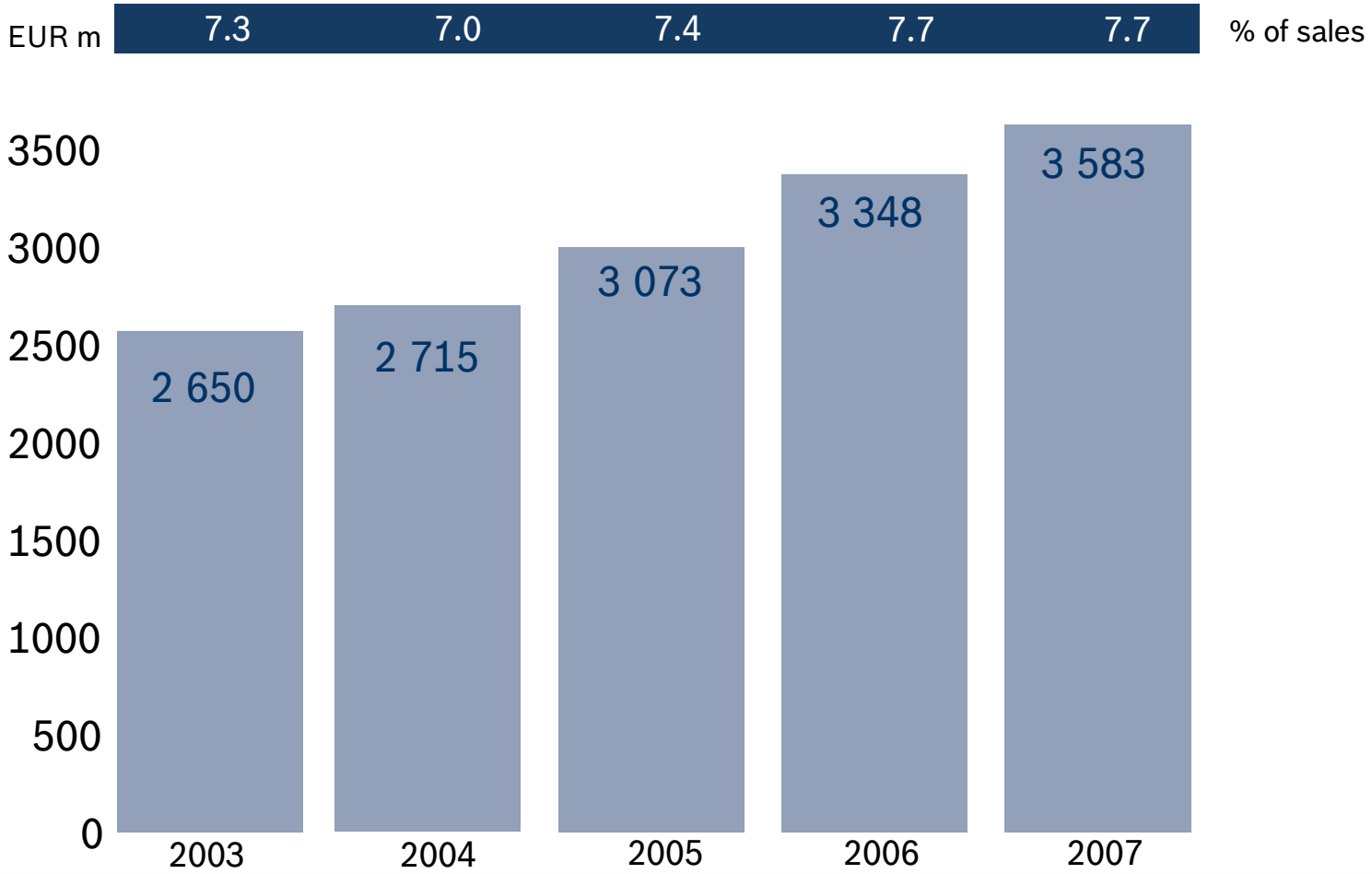
Key data

	2006	2007
Sales revenue*	43,684	46,320
Associates[1)]	261,291	271,265
located in Germany	110,480	112,300
located outside Germany	150,811	158,965
Capital expenditure*	2,670	2,634
Research and development cost*	3,348	3,583
Profit before tax*	3,081	3,801
Profit after tax*	2,170	2,850

[1)] As per January 1, 2007/2008
*Currency figures in millions of euros

Bosch Group

Research and Development Expenditure



Patents

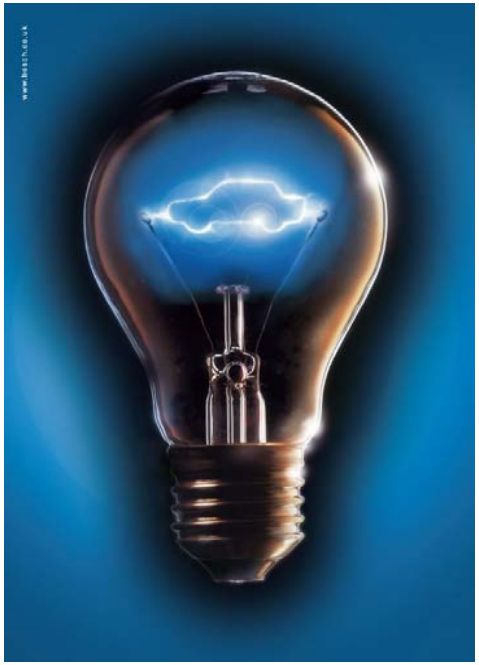
In 2007, Bosch applied for patents for a total of 3,281 new inventions (approx. 14 per day).

In April 2007, the Bosch researchers Andrea Urban and Franz Lärmer received the EU Commission's and European Patent Office's "European Inventor of the Year" award.

Bosch remains the global technology leader in the field of automotive technology, a fact which is also shown by its strong patent position in leading countries:

- **Germany:** **1st place** (German Patent and Trademark Office)
- **EP:** **1st place** (European Patent Office)
- **U.S.:** **3rd place** (United States Patent and Trademark Office)
- **WIPO (PCT):** **1st place** (World Intellectual Property Organization)

Germany, EP, WIPO: published applications for patents
U.S.: patents granted



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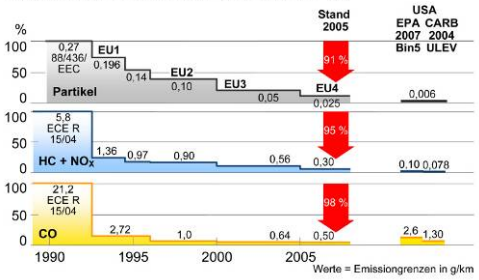
Challenges in Automotive Development

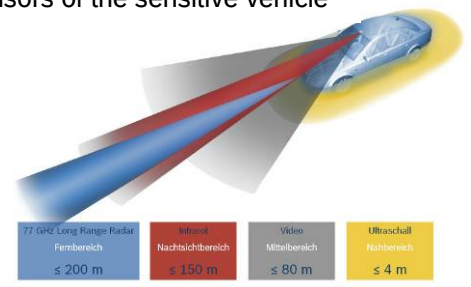
Increasing Requirements

Diesel



Reduction of emission, fuel consumption

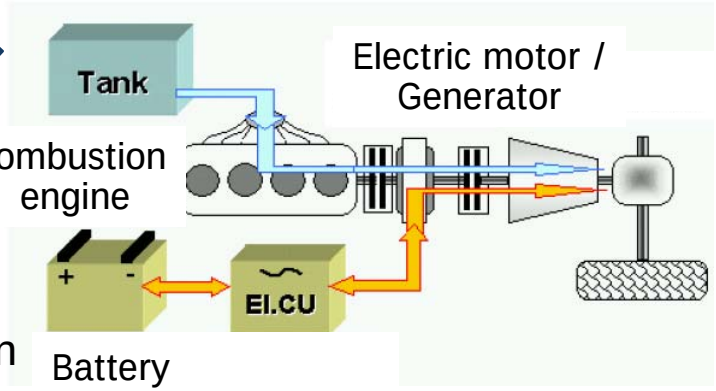
Sensors of the sensitive vehicle



Safety

Comfort

CO_2 reduction



BOSCH

Drivers of Growth – Electronics / Software

- Share of electronics in vehicle value (in value)*:

  2004: 20% → 2015: 40%

- Share of software in vehicle value (in value)**:

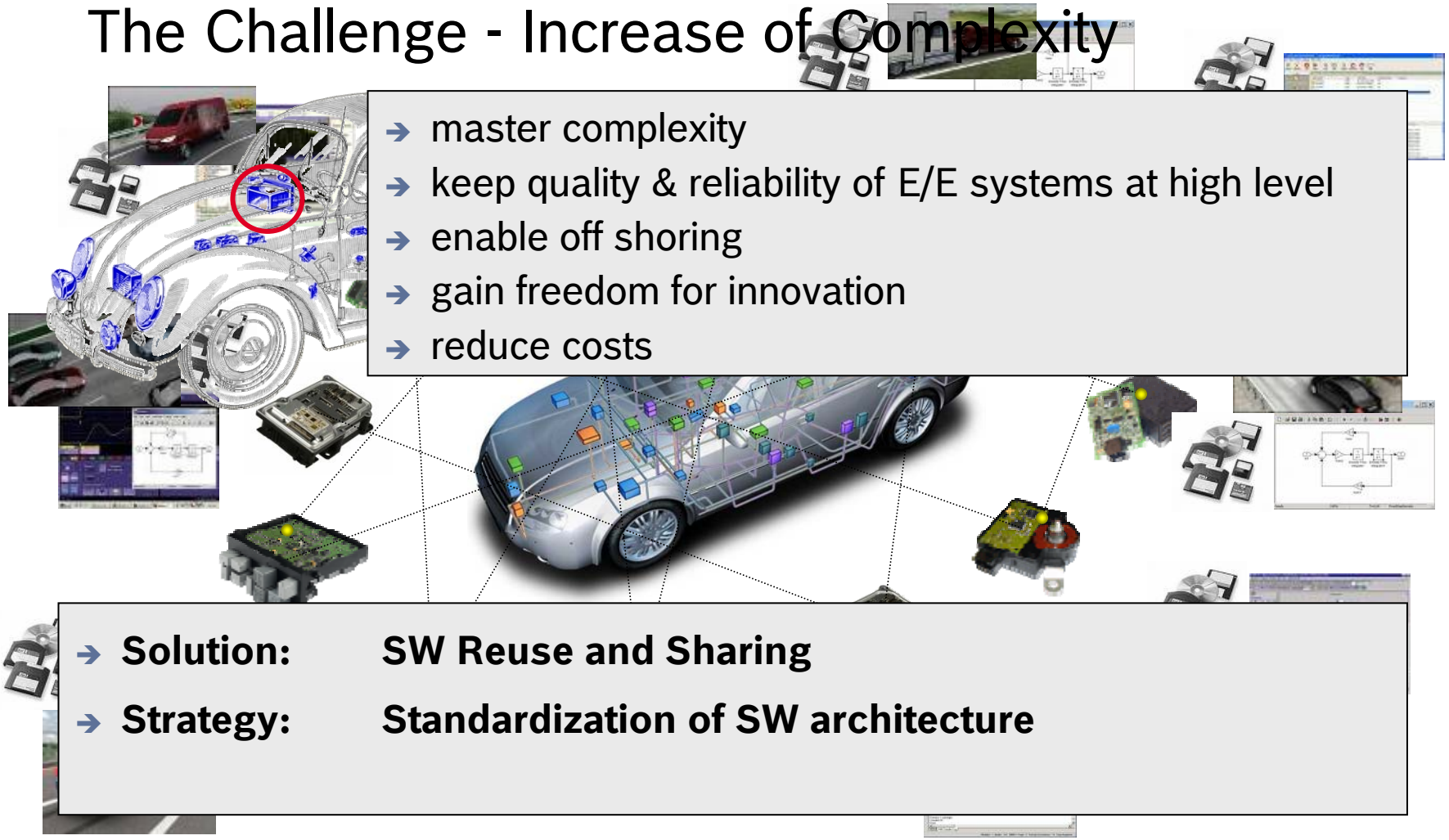
  2000: 4,5% → 2010: 13%

- Number of ECU in vehicles strongly increases
  - mid size: e.g. Golf 50 ECU
  - high end: e.g. Lexus > 80 ECU

- SW in high end vehicles reaches 1 GB

Source: * McKinsey, Automotive Electronics - Managing innovations on the road)
** Mercer Consulting, Automobile Technology 2010

The Challenge - Increase of Complexity

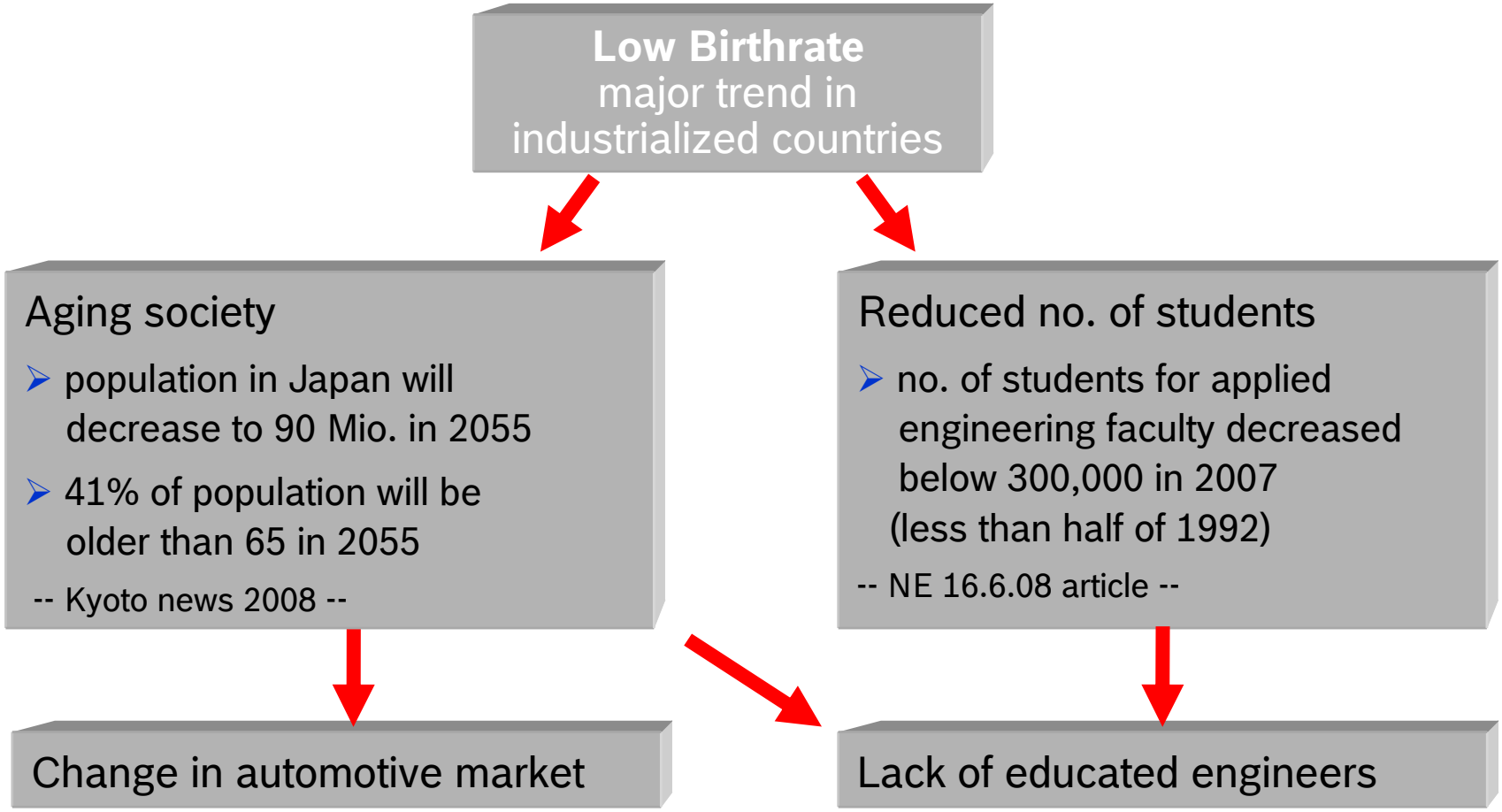


- master complexity
- keep quality & reliability of E/E systems at high level
- enable off shoring
- gain freedom for innovation
- reduce costs

- **Solution: SW Reuse and Sharing**
- **Strategy: Standardization of SW architecture**

Challenges in Automotive Development

Industrialized Countries - Shortage of Engineers



BOSCH

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Architecture Based Development –SW Reuse

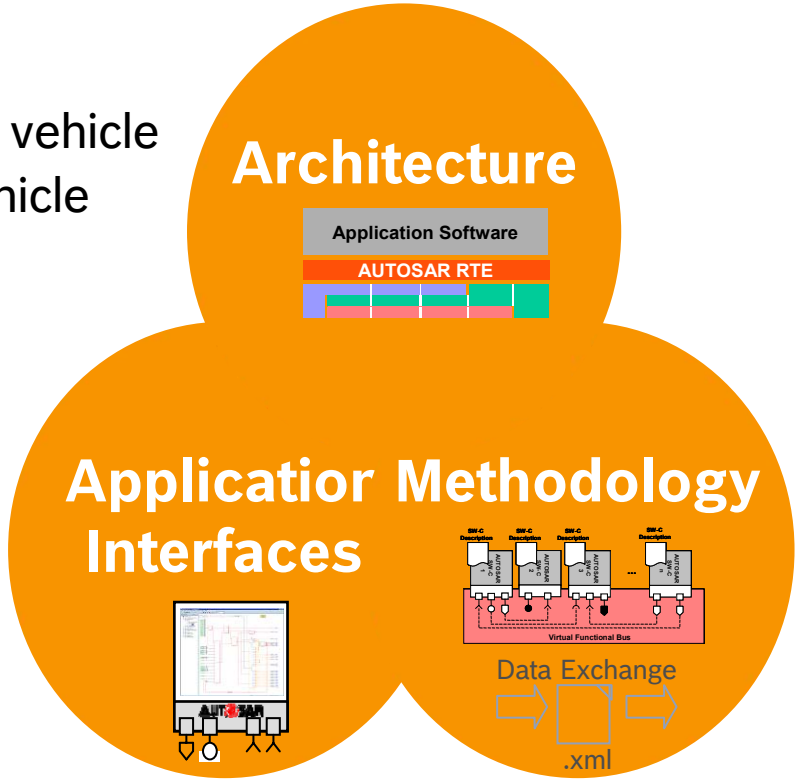
AUTOSAR

- **Architecture - AUTOSAR Basis-SW**
  - ⇨ Uniform behavior of the ECU in the vehicle
  - ⇨ Easier integration of ECU in the vehicle

    (Mastering complexity)

- **Methodology**
  - ⇨ Shift from ECU based to function based SW development

- **Application Interfaces**
  - ⇨ Support of SW re-use and SW Sharing between vehicle platforms, OEM and Tier x

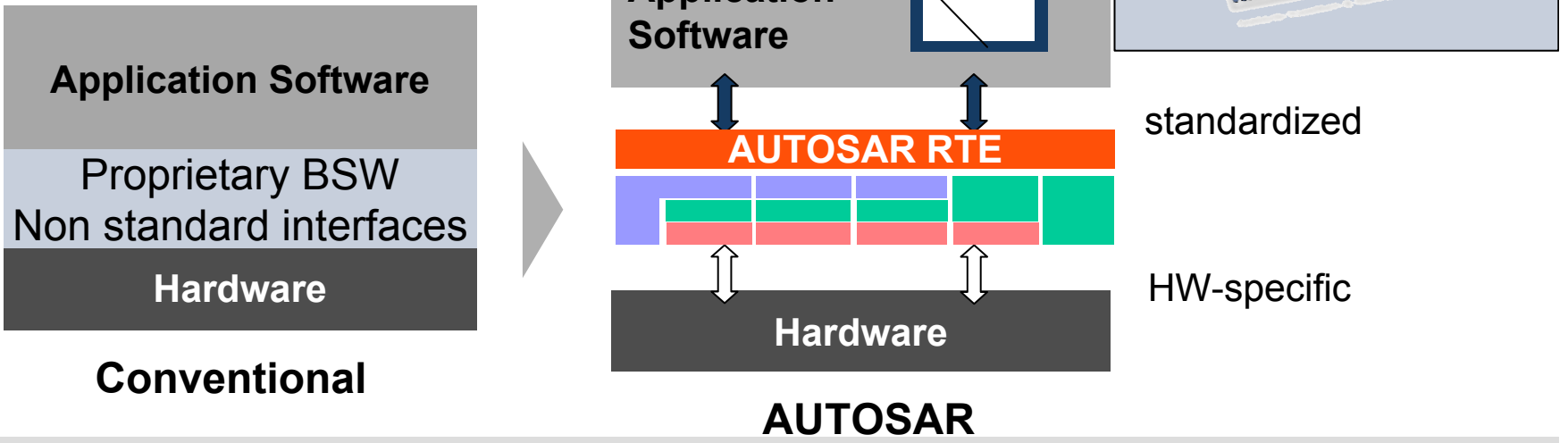


Increase of quality and reduced time to market, cost reduction by SW re-use

SW Reuse

➔ Pre-condition for integration of application software

- Standardized BSW ► AUTOSAR
- Standardized ASW interfaces ► AUTOSAR
- Well structured and modular application architecture ► e.g. Bosch



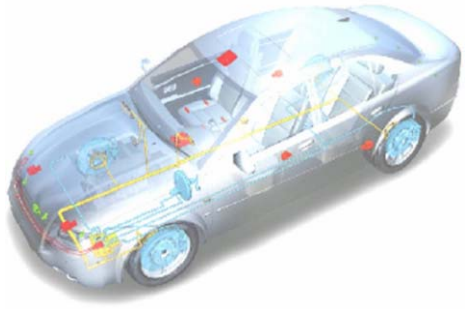
Architecture Based Development –SW Reuse

AUTOSAR Roadmap

12/2006	12/2007	8/2008	12/2009
Release 2.1	Release 3.0 • Resolved release notes • Start-up / Wake-up behavior • Application interfaces	Release 3.1 • OBDII	Release 4.0 • Error handling • Functional safety • Libraries • Conformance Test • Multi-Core • Further Application Interfaces

Status / Achievements

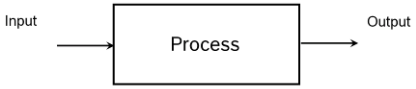
➔ AUTOSAR Rel. 3.0 / Rel. 3.1 released
Product development based on AUTOSAR started at OEM and Tier X



Processed based development

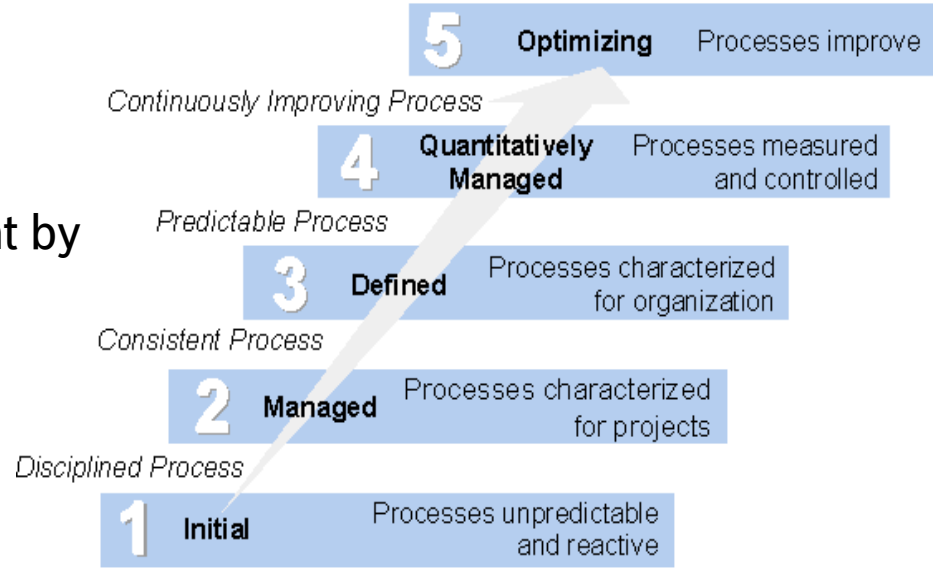
- Organization processes improvement (Capability Maturity Model Integration)

- Process steps are defined



- Constant process improvement by
  - defined processes
  - increased visibility
  - traceability

- Reproducibility



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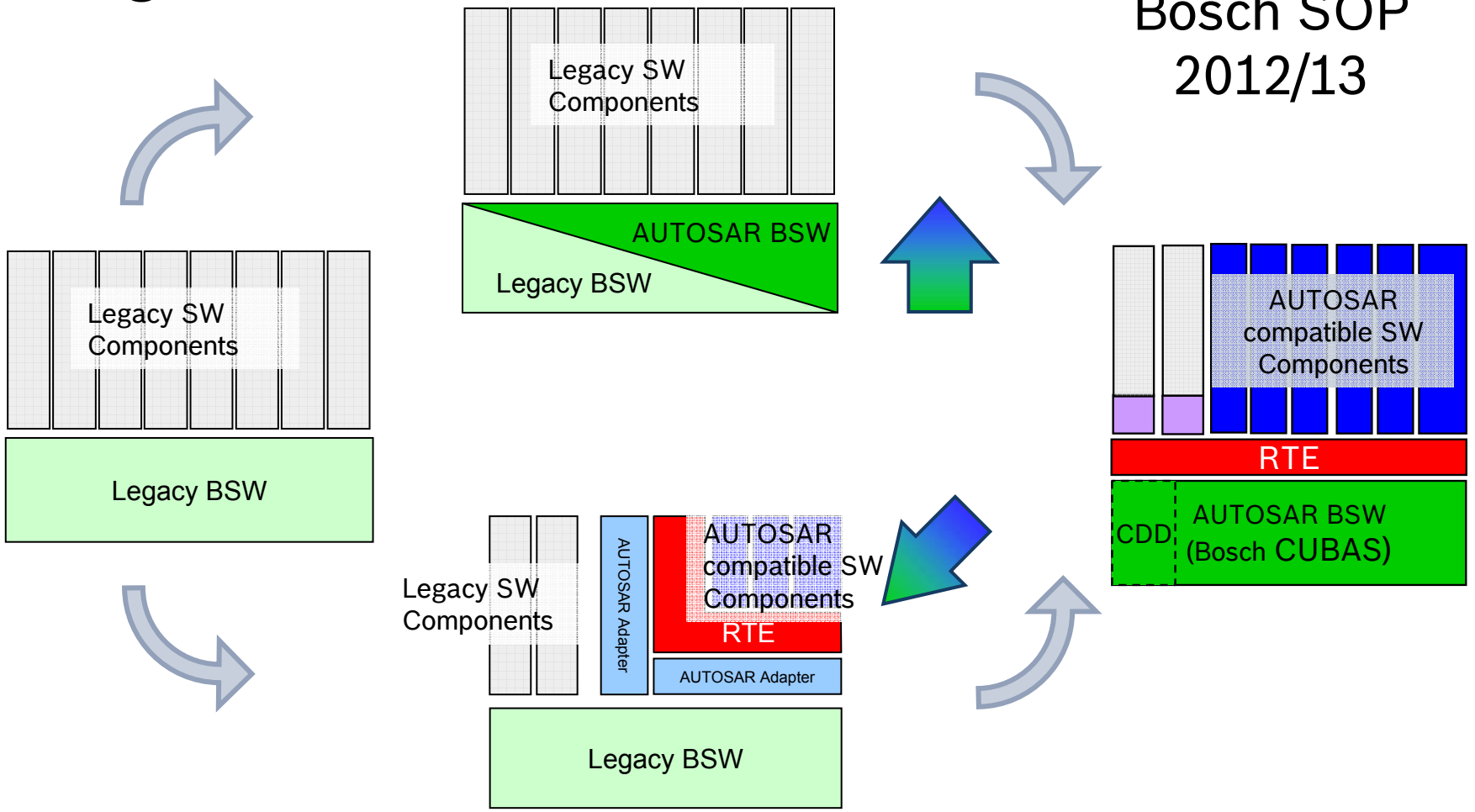
Architecture Based Development –SW Reuse

Migration to AUTOSAR @ Bosch

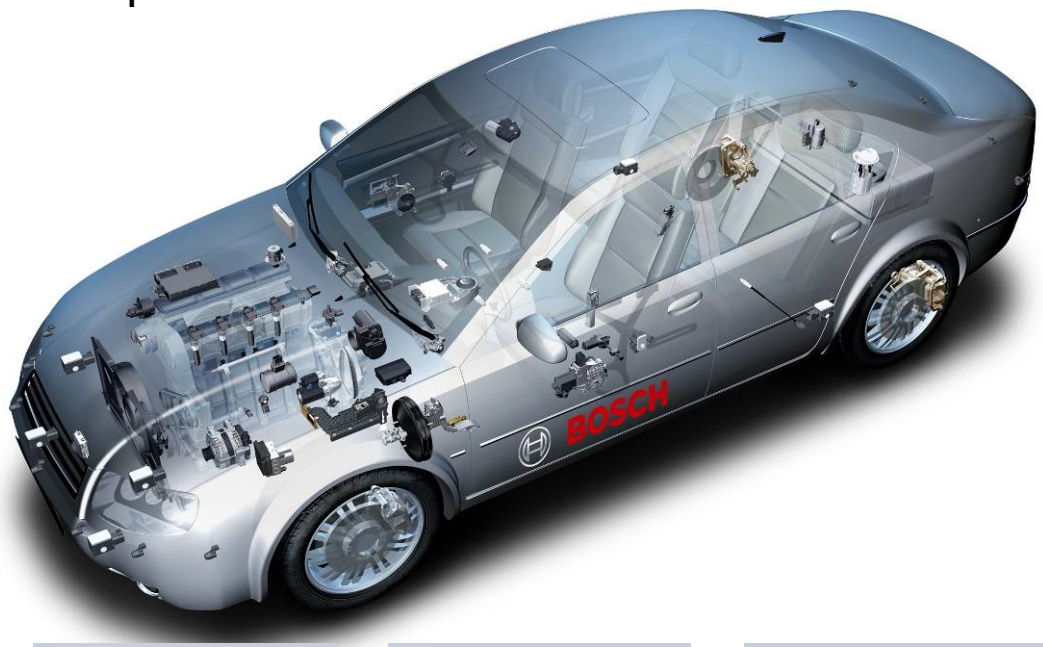


BOSCH

Architecture Based Development –SW Reuse

AUTOSAR – BOSCH Application Plan**

- All BOSCH divisions are committed to exploit AUTOSAR.



Instrument Cluster subset of AUTOSAR specs incorporated SOP 2008				**Instrument Cluster using AUTOSAR BSW*** SOP 2012
EDC/ME(D)17 ECU using AUTOSAR architecture SOP 2009				**FAS subset of AUTOSAR specs incorporated** SOP 2011
ACC subset of AUTOSAR specs incorporated SOP 2009				**Body ECU using AUTOSAR architecture** SOP 2011
Glow Control Unit subset of AUTOSAR specs incorporated SOP 2009	**Chassis DCU using AUTOSAR architecture** SOP 2009	**ESP Using AUTOSAR BSW* & Application Interfaces** SOP 2009	**Transmission Control Unit using AUTOSAR BSW*** SOP 2010	**Airbag ECU using AUTOSAR architecture** SOP 2010

* CUBAS: Bosch AUTOSAR Basic-SW ** selected products

BOSCH

Processes at Bosch

- Bosch Engineering System (BES)
  - Innovation Management
    Product Engineering
  - Project Management
    Process Management
    Knowledge Management
    Competence Management
- Maturity Model of BES is based on CMMI
- Rollout of CMMI is part of BES: Software quality by design
  - Coding guidelines according to standards – e.g. MISRA
  - Code generation (e.g. via ASCET)
  - Quality Methods (e.g. FMEA, Fault-tree, DRBFM, 6-sigma, DOE)

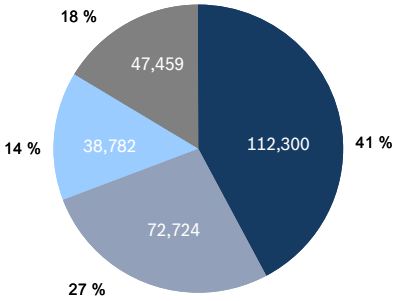
Released man power by process based development used for new innovations

Human Resources

49 Automotive Development Sites in 18 Countries

Associates

by region



Germany

Rest of Europe

Americas

Asia Pacific[1)]

Total: 271,265

[1)] Including other countries

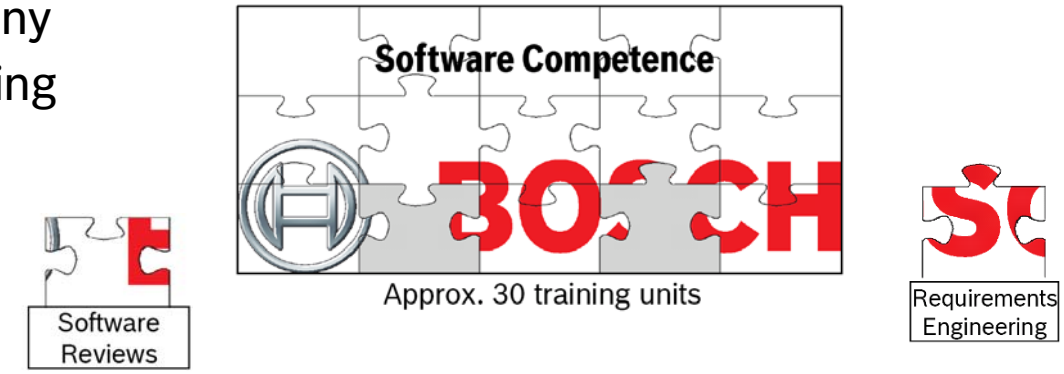
As per January 1, 2008

Development Sites with ≥ 50 Associates, Status January 2008

BOSCH

Recruiting and Training of Software Engineers

- Engineers from German university
  - reputation of engineering is growing among students
  - many foreign students in Germany (~ 10 %), especially in engineering
- Immigration of engineers from Eastern Europe
- Offshoring – Low barrier due to internationalization of business
- Systematic training of software developers
  -Curriculum Engineering Software Intensive Systems (CMMS)
- Bosch invests in Germany some 100 Mio € in training of its associates



Offshoring of Development to Bosch India

- ➔ 100% subsidiary of Robert Bosch GmbH
- ➔ No. of associates: 4500+
- ➔ Largest Bosch development centre outside Germany

- ➔ CMMI L5 (July 2006), ISO 9001:2000 company
- ➔ M2006 start of operation in Coimbatore 300 km southwest of Bangalore

Development locations at India

Koramangala (905)

Bomanahalli (Bmh)

Naganathapura (NhP)

Coimbatore (Cob)

Marketing offices worldwide

BOSCH

Embedded Offshore Development at Bosch India

Automotive Prod. - Software and ECU

- Embedded s/w
- Tools
- Diagnostics
- Testing
- h/w & s/w Dev.
- System Dev.
- ECU Projects

Business Solutions

- SAP R/3, Consulting
- Oracle, Microsoft
- Java, IBM Solutions
- User Access Mngmnt.
- Data Migration
- Web Solutions
- IT Infrastructure

Industrial Products, Consumer Goods, Building Techn.

- PLC and CNC prog.
- Engineering frameworks
- Functional Test Bench Solutions
- Plant/Manufacturing Automation Solutions
- Embedded s/w

E-Learning

- Product info/ 3D animation
- Learning Mgmt.

Electronic Engineering

- ASIC Design
- IC-Test development
- Board-Level Electronic Design
- PCB Layout Design
- SW development for ASIC and FPGA applications

Mechanical Engineering

- Design
- FEA, Simulations
- Drawings, Modeling
- Administration

Business Services Processes

- Back office support
- Comm. Center

Translation, Documentation, Web

- DE⇔EN, EN⇔JP
- Tech. & Commercial
- Digital Archiving
- Web Pages

Shared Services Accounting

- Accounts Receivable
- Accounts Payable
- General Ledger
- Fixed Assets

BOSCH

Offshoring Embedded – Key to Sustainable Success

Strategy - Offshore Support from India/Bangalore

Psychology - Advantage for Engineers and Managers
To Overcome Fear of Loss: Control/Responsibility/Job!

Commercial - Efficient Interfaces
Prerequisites are processes and architecture

Communication - Regular Contacts at All Levels

Vision - Competitiveness by Cooperation

Bosch – Associates

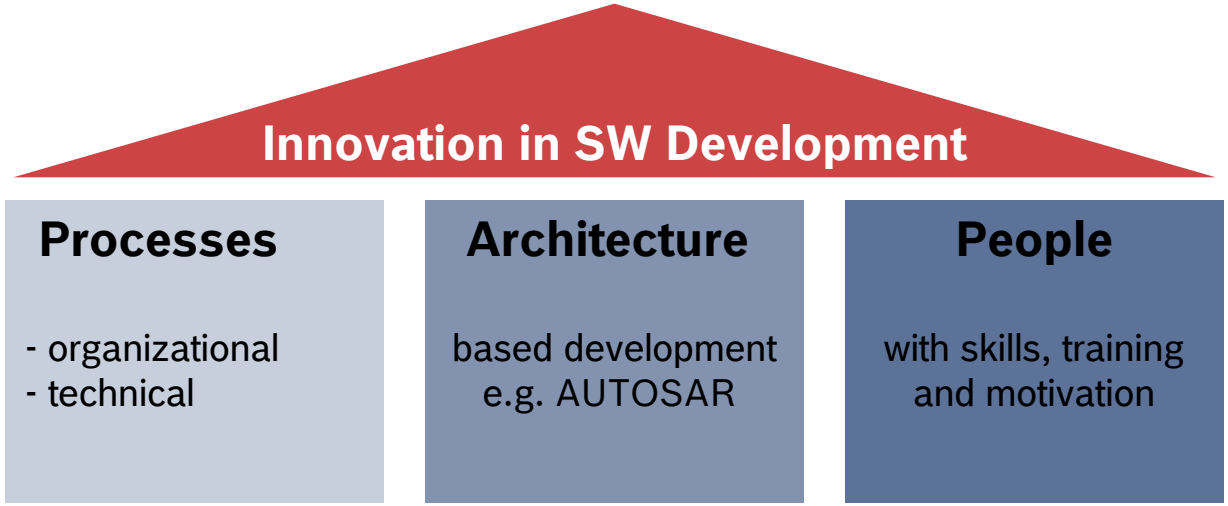
High-quality training	Every year, more than 6000 young people around the world receive occupational training at Bosch.
Attracting young talent	Bosch has considerably expanded its activities to attract young talent, especially internationally.
Support	Apart from attractive development programs for associates, Bosch attaches importance to internal career planning within the framework of its manager development schemes.
Family and career	Flextime working models, childcare, initiatives for parents, and social work help keep Bosch competitive.
Demographic change	Bosch values the experience of its older associates, and employs measures specifically designed to support them, while at the same time challenging them.
Competence management	In Germany alone, Bosch invests some 100 million euros every year in training for its associates. A structured and systematic approach ensures that the skills needed are available in the right place at the right time.
International presence	In 2007, more than 2,300 specialists and managers were working on long-term assignments outside their home countries.

Bosch Values

1. Future and Result Focus
2. Responsibility
3. Initiative and Determination
4. Openness and Trust
5. Fairness
6. Reliability, Credibility and Legality
7. Cultural Diversity

Summary

- Mastering the above mentioned challenges is the basis for innovation
- Architecture and process based software development is mandatory for efficient offshoring
- Offshoring reduces the lack in engineers (global development)
- Organization needs to support the climate for innovation



Thank You